Performance of Selective Catalytic Reduction Technology at Coal-Fired Electric Utility Boilers

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Selective Catalytic Reduction (SCR) technology has been applied extensively on coal-fired electric utility boilers in Europe and Japan. An Institute of Clean Air Companies (ICAC) report listed 72 coal-fired plants (137 boilers) in Germany, 28 plants (40 boilers) in Japan, 9 plants (29 boilers) in Italy, and 8 plants (10 boilers) in other European countries using SCR. The cumulative SCR experience at these installations amounts to more than 1700 years.

To evaluate the performance of SCR on coal-fired electric utility boilers, the U.S. Environmental Protection Agency (EPA) has initiated a project to collect and analyze NO_x emissions data from pertinent SCR installations. This paper, provides the results of this project to date. The paper examines NO_x emissions related data from SCR installations at: 5 boilers (4 plants) in the United States, 18 boilers (10 plants) in Germany, 4 boilers (3 plants) in Austria, and one boiler each in Finland and Denmark. The applicable emission limits for these boilers are briefly described below.

Three of the U.S. boilers have interim Prevention of Significant Deterioration (PSD) permit limits of 0.17 lbs/mmBtu calculated each hour (rolling three hour average). The fourth U.S. boiler is subject to a PSD NO_x limit of 0.17 lbs/mmBtu (30 day rolling average). The fifth boiler is currently subject to an interim NO_x limit of 1.4 lbs/mmBtu (24 hour average), as well as 34.5 tons/day.

The German boilers are subject to a NO_x standard of 200 mg NO_x/m^3 dry, at either 5% or 6% O_2 (approx. 0.16 lbs/mmBtu), except that one new boiler must meet a limit of 100 mg/m^3 (approx. 0.08 lbs/mmBtu). For the NO_x emissions at the German boilers, the daily average of half-hour mean values must be below the emission limit, 97% of daily half-hour mean values must be below 1.2 times the limit, and all of the daily half-hour mean values must be below two times the limit.

The plant in Sweden is subject to an annual average NO_x emission limit of 80 mg NO_x per mega-Joule (MJ) of heat input (0.19 lbs/mmBtu). Sweden also prescribes a fee on NO_x emissions from electric utility boilers. After a 1% administrative fee is deducted, all remaining revenues are redistributed to the utilities based on the fraction of total national electrical power output generated by each utility. This approach provides an economic incentive to achieve NO_x emission rates much lower than the applicable emission limit.

The Austrian plants are subject to a NO_x emission limit of 200 mg/m^3. The plants in Denmark and Finland must meet annual average emission limits of 400 mg NO_x /MJ (0.93 lbs/mmBtu) and 70 mg NO_x/MJ (0.16 lbs/mmBtu), respectively..

To facilitate comparison with U.S. data reported in units of lb/mmBtu, the European NO_x concentration data were converted to units of lbs/mmBtu . These conversions were accomplished using F-factors. For the plants that provided sufficient data on the coals used, F-factors were computed using the procedures given in EPA Reference Method 19. These computed F-factors ranged from 9,619 to 11,171 dscf/mmBtu. For the plants that did not provide sufficient coal data, emissions were converted using the Reference Method 19 bituminous coal F-factor of 9780 dscf/mmBtu. If a plant used several coals, the highest calculated F-factor was used in converting its data. This approach ensured that data conversions did not exaggerate the NO_x reduction performance of SCR.

The findings of the report are as follows.

- Using SCR, coal-fired power plants in the United States and Western Europe are achieving average NO_x emission levels between 0.04 lbs/mmBtu and 0.17 lbs/mmBtu. Further, Germany, Sweden, and Austria have boilers that are achieving daily averages consistently below 0.10 lbs/mmBtu. For the boilers that provided sufficient data for calculating thirty-day rolling averages, the highest thirty-day rolling averages ranged from 0.08 to 0.18 lbs/mmBtu.

- SCR NO_x removal efficiency for plants included in this study varied from 54% to 94%. For the plants in Germany, the efficiencies actually achieved appear to be closely related to the emission limits that apply. The efficiencies achieved at the U.S. plants appear to be somewhat greater than those required to meet the applicable emission limits.

- The Swedish plants are emitting NOx emission rates that are significantly below the applicable regulatory limit. This suggests that the economic incentives provided in the Swedish regulatory system have resulted in NO_x reductions in excess of those that would be available through compliance with the regulatory limit.

- Guaranteed ammonia slip levels are below 5 ppm for the boilers that reported this information. Eleven boilers reported actual slip levels being achieved. These levels ranged between <0.1 ppm to 4 ppm and 7 boilers reported levels of less than 1 ppm. These data show that ammonia slip levels are being controlled to levels below 5 ppm and that many boilers are achieving much lower levels, even after significant periods of operation.

- Of the 15 boilers reporting the impact of SCR on air preheaters, only those with high dust configurations reported the need to conduct washing on a regular basis. At these boilers, the frequency of washing varied from once in a 6-7 year period to once each year. Considering that annual washing of air preheaters at coal-fired plants is commonly conducted, the results suggest that at the responding plants no notable impacts on air preheaters resulted from normal SCR operation.

- Several plants provided historical information on their catalyst replacement cycles. This information indicates that, in general, a catalyst layer was replaced/added after 15,000-48,000 hours (or approx. 2-6 years) of operation. At one plant no problems with catalyst performance were noted after 50,000 operating hours (or approx. 6 years). These results suggest that catalysts are performing satisfactorily over relatively long periods of time at all of the responding SCR installations.